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AGRICULTURAL MEMORANDUM NO 511

Crop production in higher latitude, maritime regions

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I. Introduction

1. The establishment and maintenance of profitable agricultural enterprises (in which forestry and horticulture are to be included) in the higher latitudes i.e. polewards from latitude 50° - and particularly in maritime regions - encounter both opportunities and difficulties which do not emerge as significantly, if at all, in many other regions. It is the purpose of these contributions to draw attention to some of the constraints to the production and utilisation of agricultural produce and to attempt to isolate and quantify those meteorological factors which contribute to the constraints.

As illustrating the matters under consideration we may note:

(1) Timber production is a practical impossibility at 60°N in the Shetland Islands (north of the Scottish mainland), but is an important activity at a comparable latitude in Scandinavia (e.g. in the areas of Bergen, Oslo and Stockholm).

(2) Wheat is a commercial crop as far north as 67°N in Finland and Sweden, but not in Iceland - nor is it successful on a widespread basis much further south (latitude 52°N) in Eire (Lomas, 1971).

Significantly important distinctions on a considerably smaller geographical scale exist e.g. the contrast between pasture and animal farming in the western parts of southern England and the arable areas of the eastern regions.

2. In recent decades there has been a very proper insistence on the fundamental role played by photo-synthetically active solar radiation in the production of the

green plant. It is, of course, well-known that the dry matter production by all plants falls well below the level of carbo-hydrate photosynthesis theoretically possible for a given level of solar radiation (e.g. see Monteith, 1963).

Amongst the reasons advanced are:

(1) Some inherent inability of the photosynthetic mechanism to utilise incident energy more effectively e.g. arising from morphological factors such as leaf area, geometry and arrangement.

(2) The limitations imposed by certain other elements in the plant environment such as inadequate soil moisture, deficiencies in supply of plant nutrients and sub-normal concentrations of CO_2.

(3) Difficulties and hazards arising from weather-sensitive operations (e.g. cultivations, sowing and harvesting, spraying for disease and pest control) or processes (e.g. storage and transport).

It is also emphasised that, under the conditions of light and CO_2 concentration characteristic of field situations, the rate of photosynthesis of a wide range of temperate crops is largely independent of temperature between about $10^{\circ}C$ and $30^{\circ}C$ (Monteith 1966, Gaastra, 1963). Accordingly the emphasis in the literature has been to link crop production almost exclusively (often through the energy determined process of evapo-transpiration) with solar energy. Temperature (strictly of course tissue temperature, rather than air temperature - to which it is nevertheless strongly coupled) has been accorded a minor role. Such an attitude has probably been fostered by the hitherto frequent practice of using temperature (often in the form of "accumulated temperature" or "temperature sums") as an index or measure of solar energy. Such a practice was, and remains, understandable in situations where direct measurements or estimates of solar energy are not available, but such procedures should only be adopted if unavoidable.

3. However in recent decades the importance of temperature and temperature derived parameters - both as primary determinants in many phases of plant production and development and as constraints in relation to other bio-physical and biochemical

processes has been re-emphasised (e.g. Monteith and Elston: in Wareing and Cooper, 1971: pp23-42). Temperature is shown to play a dominant or an important constraining role in:

(1) Germination and emergence.

(2) Leaf expansion and development.

(3) Partitioning of photo-synthates between various parts ("sinks") of the plant - leaf, stalk, root, reproductive and storage organs.

(4) Rate of translocation of photosynthates.

(5) Phasic development (in association with photo-period; vernalisation).

(6) Metabolism.

4. The detrimental effects on plant growth and function of winds - stronger than necessary to maintain the optimum CO_2 concentration within the plant canopy - have also been extensively studied although many important problems are still unsolved. These topics will be considered later.

5. Inadequate soil moisture is not a major constraint in the regions under examination (lack of available water due to frozen soil could prove an exception). Much more serious is excessive moisture; in respect of the resulting physical effects on the soil (including "workability"), its chemical and nutritional status (arising, for example, from leaching) and as a precondition for a range of pests and diseases (of both plants and animals).